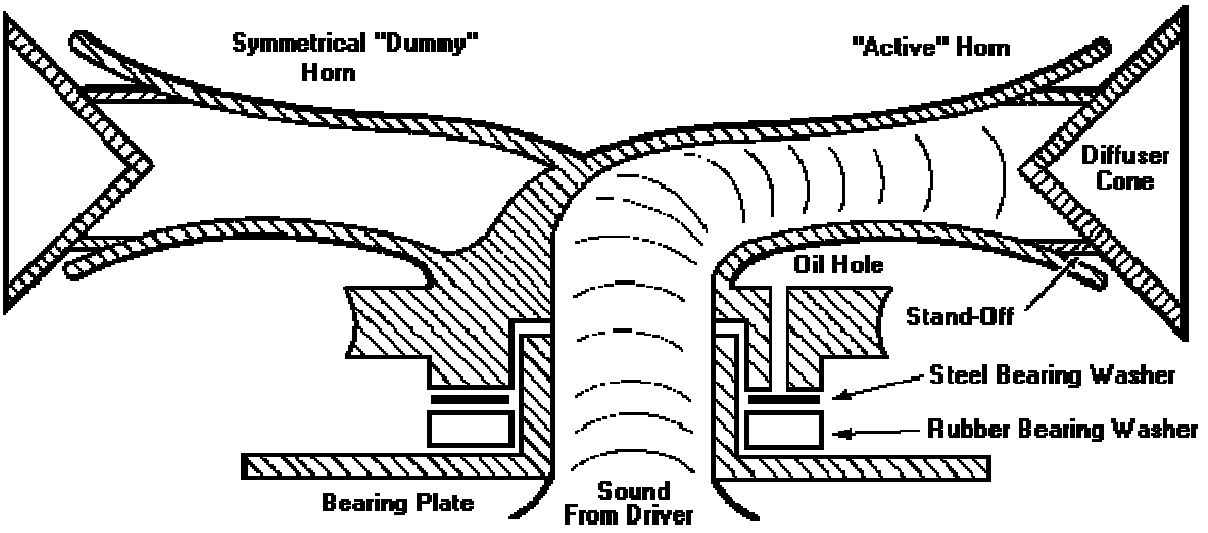

Figure 1. Plan-view of the Leslie Treble Rotor

UNEARTHING THE MYSTERIES OF THE LESLIE CABINET

by Clifford A. Henricksen
Community Light & Sound

First published in Recording Engineer/Producer magazine, April 1981.

The Leslie Rotating Tremolo Speaker System has produced the same unmistakable sound for so many musicians that it has become an international institution for the recording and performing musical arts. Everything from the venerable Hammond B-3 organ, to human voices and electric guitars, have been processed by the Leslie Sound, and have ended up on countless hit records. This article is an attempt to unearth the mysteries of its operating principles, and includes a discussion of the Leslie Cabinet's practical use in both stage and studio situations.

My love-hate relationship with Leslie Speaker began with the purchase of a Hammond organ during the mid-Sixties. The salesman told me I would probably end up buying a Leslie for it, a statement that I dismissed as the usual sales banter. Besides, at the time I had no idea what a Leslie was anyway. The Hammond was purchased because that's what the Animals' organist, Alan Price, used on all the group's early hits, especially "The House of the Rising Sun." I saw the band live in Schenectady, New Youk, where they put a Hammond M-102 direct into a Fender

Bandmaster Amp, and I *had* to have this sound. I soon discovered, however, that my new musical heroes had *better* sound. It wasn't long before I knew that Booker T. Jones, Felix Cavaliere, Gary Brooker and Billy Preston (and many others) were all using Leslies. *This* was The Sound!

My first Leslie, a single-speed Model 45 with a 40-watt tube amplifier sounded great, but it literally got lost in the roar of the Boston-based rock and roll band in which I was then playing. Two big Leslie Speakers were cumbersome to move, they weren't a big improvement in level (plus 3 dB), and the high-frequency drivers broke. From then on, it was guerilla speed shop tactics (mill the heads, oversized pistons, etc.), to the point where I could finally be heard over any guitar player. As a result, I became an expert at Leslie repair, modification and special use, occasionally even letting a few guitar notes into my beloved machines. I've spent the past 15 years in and out of the Music Business, both in studios and on stage. The significant part of this time was spent in some way dealing with Leslie Speaker Systems. As you might guess, this is a rock and roll story. I might as well show my bias here and now. With this in mind, here's what I have learned over the years.

PRINCIPLES OF OPERATION

First and foremost, the Leslie Rotating Speaker is designed as *a sound modification device*. It is not a "Hi-fi" speaker, but rather a part of a musical instrument. You buy a Leslie to *change* the sound of an instrument, not to reproduce it.

The Leslie Speaker System, thoughtfully named after its inventor, Don Leslie, operates on a simple principle: a directional sound source is rotated at constant (or variable) speed around a fixed pivot point.

At a listening point some distance from this whirling affair, three things happen. First, because the source is directional, the intensity of the sound will be at a maximum when it points at the listener (or microphone), The sound intensity will increase as the rotating source approaches dead center, and decrease as it rotates past this point. The resultant effect is called amplitude modulation (AM), which is no big thing, and is a feature on any guitar amp with a "vibrato" or "tremolo" feature. By moving closer to the rotating speaker, the inverse square law will increase the modulation effect.

However, the *big deal* is the Leslie's ability to create frequency modulation (FM). As the source rotates toward the listener, its relative velocity will increase the pitch of any tone it produces; as it rotates away, the pitch well be lowered. This is exactly the same Doppler effect that causes a train whistle (or any other sound on the train, such as grunting pigs, or shrieking passengers), to rise and then fall in pitch as the train approaches and then passes.

Lastly, if you are listening in a room with any significant reverberation, a complete spatial modulation of the sound will happen, as sound is "shot" all around and goes through multiple reflections.

If you want a real treat of all kinds of bizarre whirling horns and things, order copies of Don Leslie's original U.S. Patents: RE#23,323 and 2,622,693, available from The United States Patent Office, Washington, D.C.20231, for a fee of 50 cents per copy.

These patent specifications are incredibly entertaining documents, and a must for any Leslie fan.

The Real-Life Leslie

A practical and commercial manifestation of the Leslie principle may take on many forms. Indeed, the manufacturer of Leslie Speakers, Electro Music, Inc. (now a division of Hammond Organ), produces a wide variety. These include models with reverberation, triple channels, and rotating-cone speakers. However, any Leslie afficionado will tell you that the Leslie Models 145, 147, and 122 are the ones with "The Sound". All three Models share the same basic innards: a 40-watt monophonic tube amplifier; an 800 Hz 16-ohm passive crossover; a rotating treble horn and a rotating bass speaker. Both rotating speakers are available with slow and fast A.C. induction motors. (Older Models 45, 47, and 22 are *identical*, except for having single-speed rotors.)

Furthermore, these Leslie models are similar in that they all have components mounted in a three-compartment cabinet. The top compartment houses the rotating high-frequency horn; the middle "box" the high- and low-frequency drivers and crossover (and which also acts as a vented box for the low-frequency driver); and the bottom compartment the low-frequency rotor and amplifier. Louvres located in the top and bottom compartments let out treble and bass sound respectively. All the above speaker systems are virtually identical in terms of their use and sound quality. (The larger Models 147 and 122 allegedly have a better low-end.) Both high- and low-frequency speakers operate on the same principle: a stationary driver (loudspeaker) and a rotating acoustic "projector".

The "Treble Rotor"

The Leslie's high-frequency unit is largely responsible for the "Leslie Sound". Some organists actually find that the bass rotor's slower response to speed changes is distracting, and will actually disconnect the bass rotor drive - especially when playing a bass line. The treble unit consists of a stationary 3/4-inch throat Jensen compression driver, connected to a vertical tube that acts as a thrust bearing (Figure 1). A twin-bell, molded black bakelite horn, which starts vertically but flares horizontally, sits on this bearing/tube, and rotates via a two-speed A.C. induction motor fitted with three (selectable) drive pulleys. This motor drives the treble horn at fast or slow speeds via drive belt and belt tension spring. Direct current is sometimes applied to the "fast" motor so that it will slow down more quickly; this is called a "D.C. brake". The treble horn actually looks like two horn assemblies; in fact, only one is operable as a horn. The other side, a "dummy", acts as a counterweight or dynamic balancer, providing symmetric air drag at high speed. The resulting structure rotates smoothly and without eccentric "wobble" forces.

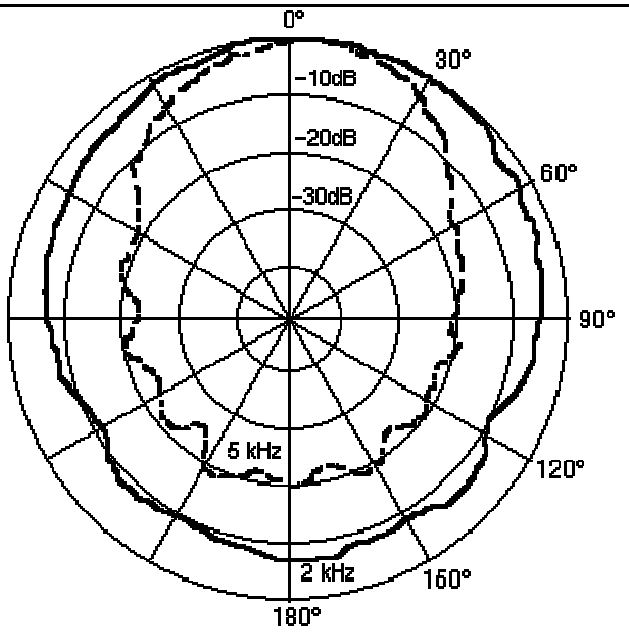

Figure 2. Typical polar response patterns of the Leslie Treble Rotor, with the deflectors removed.

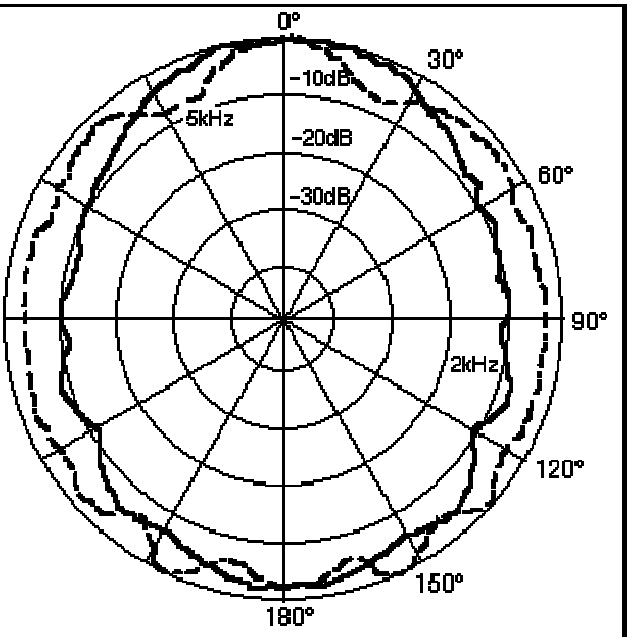

Figure 3. Typical polar response patterns of the Leslie Treble Rotor, with the deflectors in place.

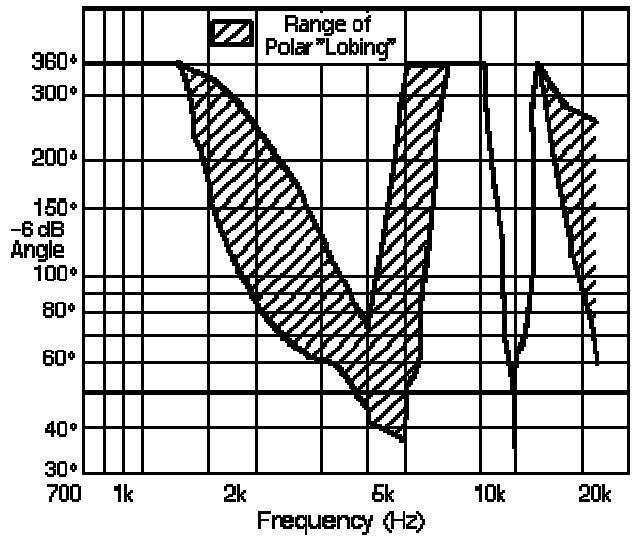

Figure 4. Coverage angle of the Leslie treble horn, with the deflectors in place.

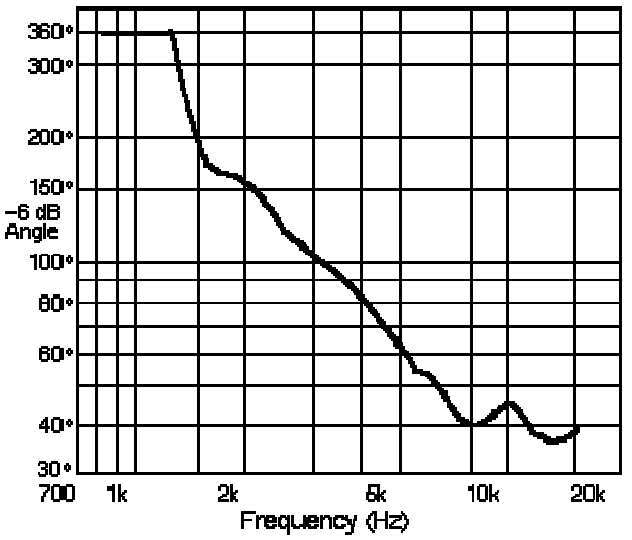

Figure 5. Coverage angle of the Leslie treble horn, with the deflectors removed.

At the mouth of the horn is diffuser cone, which is supposed to widen the dispersion of the horn and make a "more musically pleasing tone". Actually, it does work. Figures 2 and 3 show typical polar response charts of a Leslie Horn with and without the deflector; the results are dramatic. The "without" curve of Figure 2 is typical of a "beamy" straight horn, with a lot of sound concentrated on-axis and very little sound off-axis. The "with" polar response curve of Figure 3 is almost omnidirectional; note, however, the "lobing". As the horn revolves, the sound will actually rise and fall a number of times, giving it an even more characteristic sound.

The horn's so-called coverage angle is taken from polar response charts such as these; it is the included angle between -6dB points from the horn's on-axis level.

Figure 4 and 5 show such coverage angles, compiled from a series of third-octave polar response curves. Note how the beamwidth gets smaller and smaller without the deflector. This means that if the deflectors are removed the sound will be much hotter on-axis, but much softer off-axis. Therefore, the AM portion of the Leslie Sound will be much more severe and "choppy", as many a rock and roller will tell you. Many Leslies played in clubs are faced backwards, with the top and bottom rear panels and deflectors removed, because the sound "cuts" better; an effect that translates as, "You can hear it better over the guitar player".

This beaming process will actually raise the on-axis sensitivity of any driver, as can be seen from the frequency-response curves of a University ID-40 driver (a respectable, but typical 3/4-inch throat PA unit) mounted on a Leslie horn with and without deflectors (Figures 6 and 7). It is interesting to note the extra sensitivity above 1.5 kHz available without the reflectors in place. (Note also that the low-end - 800 Hz to 1.5 kHz - response isn't affected by removing the reflector, and that the response is ± 5 dB from 400 Hz to 10 kHz. This latter range could be made even flatter with a real-time analyzer and an third-octave equalizer in the studio.)

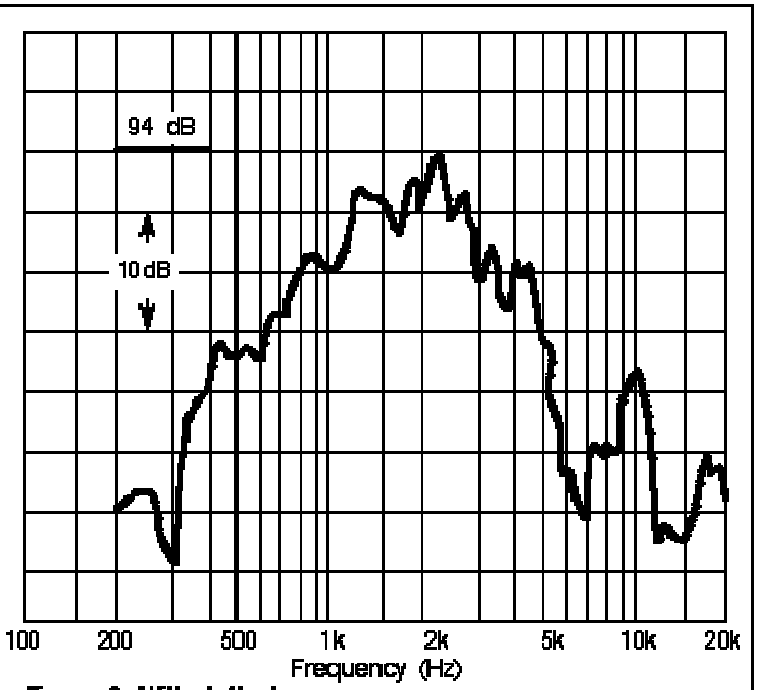

Figure 6. With deflectors

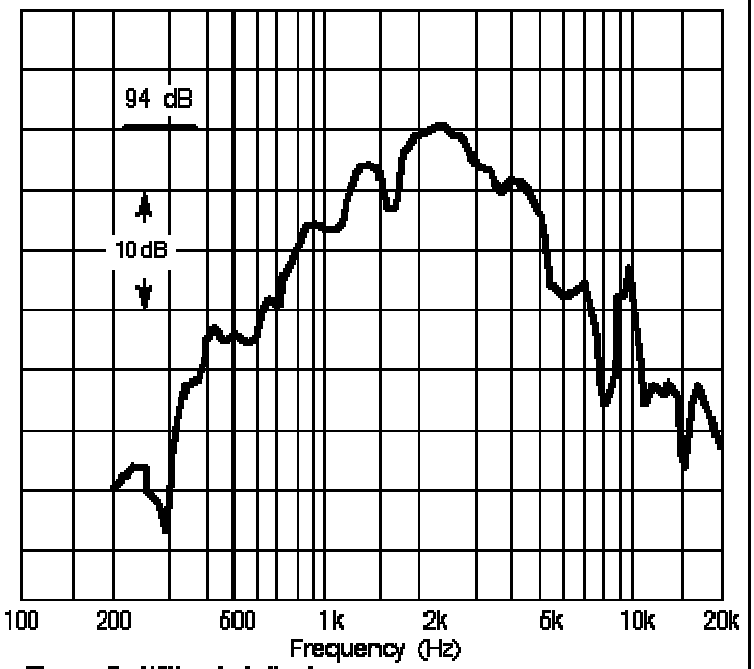

Figure 7. Without deflectors

Now, this entire discourse is based on the treble horn measured in an anechoic or non-reflecting, highly absorbent room. In real life, the horn mounted in a louvred wooden box, which means that the picture changes somewhat with resulting internal reflections. The diffuser cone does another important thing: it shifts the apparent sound

source position on the horn. With the cone *in*, more of the entire range of the horn will appear to come from the mouth of the horn; with it out, however, while lower frequencies still appear to come from the mouth, higher and higher frequencies will appear to come from progressively further down the throat. They therefore appear to be rotating at a *smaller* radius, which results in less frequency modulation effects. (If the directional sound source was rotating at dead center, there would be no FM effect at all.) So here you are faced with a choice: leave the deflectors in place and the result will be maximum frequency modulation, and a relatively lower amplitude modulation, because of the very wide directional characteristics of the horn. Take the deflectors out though, and the FM will be lost, but you obtain very strong AM - especially at higher frequencies - due to the very narrow beam width of the naked horn. My own ears tell me that the deflectors should be kept on, but you make your choice and you take your chances!

The "Bass Rotor"

In the lower compartment of the Leslie box is a rotating wooden drum mounted on a vertical shaft, and covered with a black scrim cloth, which provides lower aerodynamic drag on the drum at fast speed (Figure 8). It also works. At the drum's center is a cylinder fitted with a "scoop" which, as in the treble unit, starts vertically (the bass driver faces downward into its entrance) and projects sound horizontally. The drum assembly is driven with a two-speed motor, and ends up at approximately the same rotational speed as the treble unit. The only difference is that the drum's inertia makes it approach final speed over a much longer time period. A D.C. braking voltage can also be applied to the "fast" motor to slow down the speed more quickly when switching from fast to slow. This system works somewhat effectively.

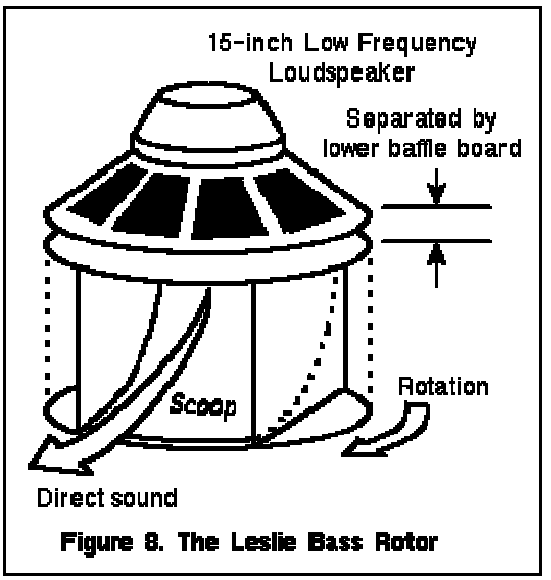

Figure 8. The Leslie Bass Rotor

To my ears and powers of reasoning, the bass rotor works just as an AM device, and only for the upper two octaves or so of the bass section (200 to 800 Hz). Frequencies lower than 200 Hz are probably uneffected by a scoop of this size, since 200 Hz has a wavelength of approximately 5.5 feet. There may be some frequency-modulation effects near the 800 Hz xrossover point, but it sure sounds like AM to me. The result is a low-frequency "throb", which is very pleasant and especially powerful and beautiful when used in "slow" or "chorus" mode.

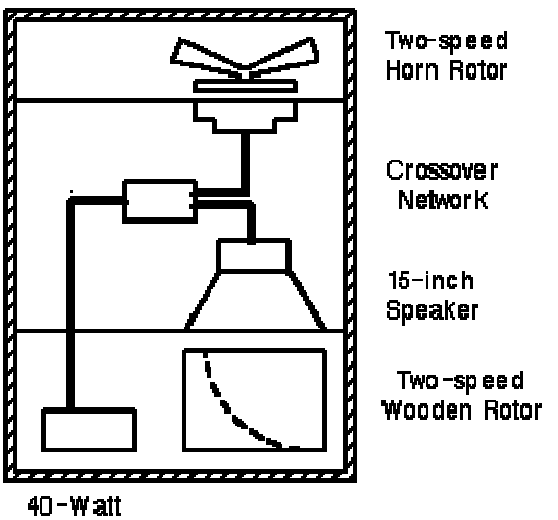

Figure 9. Schematic diagram of the Model 147 Leslie Speaker System

The Complete Leslie System

With all these rotating components

installed in the box, the System works as follows: an electical signal is sent into the Leslie amplifier driving a 12 dB per octave, 16-ohm crossover, which feeds the 16-ohm bass and treble drivers with the appropriate frequency bands (Figure 9). Input signal, motor controls, and A.C. line voltage (115 V, 60 Hz) are connected to the unit via special plugs and sockets, linked with the "Leslie cable". It is this latter cable that's a major problem for many who would like to use a Leslie. Most self-contained speaker systems have an A.C. cord that plugs into the wall, and an input jack for the music signal. The Leslie, however, has a "Leslie Cord". Just one of the things with which we Leslie fans have to live.

The amplifier chassis contains a 40-watt amp fitted with 6550 tubes - a *wonderful* choice of output tube for instruments - and motor control circuitry. Each rotor is actually driven by two separate motors (fast and slow) mounted in one package. Therefore, there are a total of four rotor motors and four pairs of wires, which all plug into the amplifier chassis. If any of these wires are removed and plugged into a live A.C. outlet, the appropriate motor will turn on safely without any problem, since this is essentially what the motor control does.

Input to the amplifier is via the six-pin plug. The speaker and crossover are both connected by very odd little two-pin connectors that I have never seen in use outside of a Leslie Speaker. They work, however, and seem to be very reliable over long periods of time.

Getting Music In And Out Of A Stock Leslie

Picture the scene. You have just bought a used Leslie; you got a great deal on it just in time for the gig. You excitedly load it up, set up your Farfisa organ and then stare dubfounded at this ugly, black 6-pin Harvey-Hubble *plug*, the only connector visible on your Leslie. Your 1/4-inch phone plug cord hangs limply in your hand... useless... impotent. Mistress Leslie stares back coldly. You can't even plug it in the wall and watch the tubes glow!

Chorus Interruptus... The Horror!

Well, it's a real problem. But, *veehaff vays to do ziss, Fraulein Leslie*. Here's how.

If your studio has a Hammond B3 or C3 organ with a Leslie attached, the latter will probably be a Model 22 or 122. This is a quiet, reliable and troublefree system, although you still can't plug it into the wall and operate the Leslie *independently of the organ*. Most big Hammonds, like the B3 and C3, will have a Leslie plug installed on them. Be careful! Only connect a Hammond Organ to a Model 122, 22, or 122RV; never connect a Hammond via a "Leslie Cord" to a Model 147 ot 145 Leslie. It will basically blow up. Inside the organ a very simple connection can be made via the RCA phono jack fitted to the "expression control box". This jack can be located by taking the back off the organ and merely plugging in. It is a line-level input that will accept most relatively high impedance signals.

A recent welcome accessory to the Leslie line is the Leslie Combo Preamp. These little beauties actually booost the signal of an instrument to the required level, provide A.C. power for Leslie's amplifier and motors, and have foot switches to change speeds. It also plugs into the wall (via a *real* A.C. cord), connects easily to most

instruments (a *real* 1/4-inch phone jack), and attaches the preamp to the Leslie via the standard Leslie Cord.

You may want to build a customized system for your own special use from a stock Leslie 147 or 145. (You'll *probably* want to modify it - this comes later.) Any modifications that involve poking around within the power amplifier should be carried out with *extreme* caution. Remember that the Leslie speaker is fitted with a *tube* amplifier, which has a power supply voltage of over 400 VDC. I've heard that, if you're a player, such a shock can improve 128th note runs, but I wouldn't recommend it. Watch where you put your fingers!

Engineering your own system is actually a simple matter, once you can locate a 6-pin plug that is compatible with the one fitted to the amplifier (or buy a Leslie Cord). Pin 1 is signal ground, and pin 6 signal "hot". Any source capable of delivering over 6 V into a load of 2.5 kohm, or less, will be able to drive the Leslie amp to full power with the "console load resistor switch" set to "open". The switch also inserts an 8-ohm, 10 watt or 16-ohm 10 watt equivalent resistor across the input, which means that a 10-watt power amp could be used to drive the Leslie, with the level control at the right setting. This is the typical setup for many organs equipped with their own power amps. A small guitar amplifier, such as a Fender Champ would do fine. The speaker should be disconnected, and the switch set to "8 ohms". Don't try it with a large power amp, however; your Leslie will sound, and smell, very bad shortly after the input resistors burn up.

Input power (115 VAC) connects via pins 3 and 4. Pins 2 and 5 connect the 115-Volt A.C. coil of the tremolo relay, which is "fast" when off, and "slow" when on. Therefore, a D.P.S.T. switch connecting pin 2 and pin 3, and pin 4 to pin 5 will activate the relay; if you only want "fast" forget pins 2 and 5. (A simpler approach would be to make a direct connection from pins 4 and 5, and use a simple S.P.D.T. switch.)

Modifications To The Leslie

Ah, yes. Audio racing in the streets. Imagine thousands hearing a vocal track through a Leslie... a Leslie that can be heard over a guitar player's Marshall Stack... a clean, Hi-Fidelity Leslie. These things and more can be yours, given the cash outlay in proportion to the desired grandeur, and even more cash if you don't build it yourself. (This country is loaded with local Leslie "speed shops" - and there will probably be 50% more after this article is published.) Electro Music makes Fenderesque Bi-Amp Leslies in vinyl cabinets. However, they are expensive, and are only equipped with amplifiers rated to a maximum of 60-watts. Also, you may very well want to preserve the present walnut beauty and improve its performance. If so, here's how:

External Mono-Amplification

The stock Leslie Models 145, 147 or 122 have a marvelous 40-watt tube amp. When you *really* lean on it, it sounds even lovelier, with a warm rich distortion like nothing you've heard. The show organist at Circus-Circus, Las Vegas has the best sound of this kind I've ever heard. He runs his Hammond B3 on 10, and just keeps the hammer down. However, in a live band situation or a club, or worse, at a concert, even a single 40-watt Leslie just doesn't cut it, even for a keyboard only. The recent rapid expansion of concert sound techniques allows quiter instruments to be miked and simply turned up at the console. I'm told that Keith Emerson and others have

actually installed and miked a Leslie in an isolated backstage room during their concerts. (Including Bruce Springsteen's keyboard player, Danny Federici; *R-e/p, February, 1981 - ed*.) The result is a clean Leslie sound with no on-stage bleed from other instruments. In many cases however, a performer prefers more direct level from their own instrument.

The simplest way of enhancing the sound of a Leslie is to disable the built-in amplifier (pull out all four tubes and/or the fuse) and use the motors only, via a combo preamp or the adapter discussed earlier. The speaker system can then be connected to whatever amplifier you plan to use. This is achieved by disconnecting the crossover from the standard Leslie amplifier, and patching it to a convenient input socket. A 1/4-inch phone jack, or a much-better-but-less standard banana or GR plug would be the answer. A more versatile method would be a 1/4-inch jack which, when accessed, disconnected the crossover input from the Leslie amp, and connected it instead to the jack. The only problem remaining is the power handling capablility of the Leslie Speaker System components, namely the high- and low-frequency drivers and the crossover networks. I'll discuss these as separate modifications.

Treble Driver Modifications

The stock Leslie high-frequency driver is pretty fragile, and is easily overloaded with a stock 40-watt amplifier. Unless for some exotic reason you want to drive it at low levels, plan on a new driver. Choice of drivers is important, and the most expensive ones are not necessarily the best answer. The most expensive professional drivers from Altec, JBL, Electro-Voice, and others, have usable sound reproduction to within the 10 to 20 kHz octave. Such performance probably won't be needed for a Leslie - I'm told that, in fact, a very high frequency harmonic content is actually a deterrent.

Extended-band high-frequency drivers are also rather fragile; a percussion note from a Hammond B3 can easily send a 0.002-inch thick aluminum diaphragm through its full

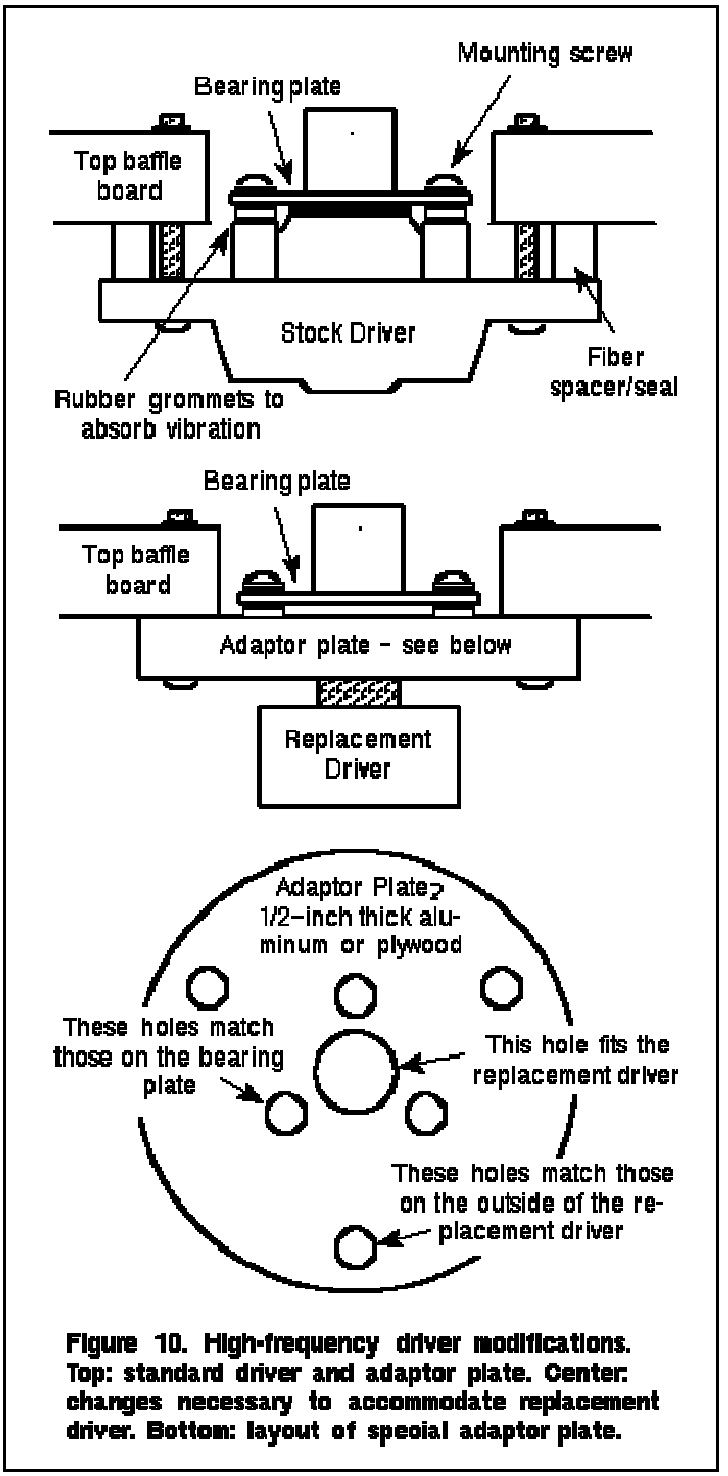
Mounting screw
Bearing plate
Top baffle board
Stock Driver
Fiber spacer/seal
Rubber grommets to absorb vibration
Bearing plate
Top baffle board
Adaptor plate – see below
Replacement Driver
Adaptor Plate? 1/2–inch thick aluminum or plywood
These holes match those on the bearing plate
This hole fits the replacement driver
These holes match those on the outside of the replacement driver

Figure 10. High-frequency driver modifications. Top: standard driver and adaptor plate. Center: changes necessary to accommodate replacement driver. Bottom: layout of speoial adaptor plate.

excursion, and into the driver's phase plug. At this point, the musician is off the air, possibly during a now favorite solo, or in the middle of a take. Also, these drivers have large throats (between 1.4 and 2.0 inches in diameter), whereas the entrance hole to a Leslie treble horn is about 3/4-inch. This makes it ideally suited for the 3/4-inch throat PA drivers fitted with screw mounts, such as those made by University, Electro-Voice, Atlas, etc..

Such drivers are relatively cheap, can easily reproduce up to 5 or 6 kHz, and some handle enormous amounts of power. They also have a very similar bandwidth to the stock Leslie driver, which means that the same sound quality will be maintained. Actually, replacing the treble driver would make a stock Leslie much more reliable for "leaned on" use. My own personal preference is the Electro-Voice 1829 driver, a 16-ohm unit ideally suited to the Leslie crossover. I used one on stage for years at full chat with a Bogan MO-100A 100-watt tube power amp. It's still intact and has a pleasing sound. I'm told by numerous others that the have had similar good luck with an E-V 1829's sturdiness and power-handling ability.

Replacement of the Leslie driver involves, first, removing the backs from the upper and middle cabinets to provide access to the driver and horn. A special adapter is necessary to fit the screw throat PA driver to the stock Leslie horn, as shown in Figure 10.

Bass Driver Modification

The stock Leslie Bass Driver is a 15-inch O.E.M. speaker capable of handling about 50 watts. Supply it with 40 watts of a 30 Hz pedal tone and it shakes a lot. You may also be getting dangerously close to the driver's excursion limit, but it seems to be pretty sturdy. I've certainly heard of them breaking with "stock" use. If only a keyboard is used through the system - one without a lot of deep bass - and you protect the driver by filtering out the low-end, the unit may handle lots more as you approach its "thermal limit". If you want to avoid running the risk of breaking the bass driver, the easiest solution is to replace it with another unit capable of handling higher loads. Speaker choice is left up to the individual; since it's a matter of taste I can't really recommend any. An 18-inch speaker will fit with the following modifications: a spacer ring has to be added between the speaker and the Leslie baffle (so that the cone doesn't hit it), and part of the back panel may have to be whittled out for certain larger 18-inch speaker frames.

Crossover Modification

The stock Leslie crossover is a 12 dB per octave, 800 Hz unit requiring both 16-ohm high- and low-frequency drivers for correct performance. Most "mondo-power" 15-inch woofers have an impedance of 8 ohms, which tends to extend the reponse a bit higher than 800 Hz. Although this shouldn't cause any difficulties, it will make an 8-ohm high-frequency driver extend a bit lower, which will definitely cause excursion problems. The answer is to either buy a 16-ohm replacement driver, or perform the following modifications.

If the Leslie is fitted with both 8-ohm high- and low-frequency components, a stock 800 Hz crossover can be obtained from JBL, Altec, and other manufacturers. Community Light & Sound makes a very good crossover, which requires an 8-ohm bass speaker and a 16-ohm treble speaker (if you use it without its attenuation pad).

The crossover handles well over 200 watts RMS, and is made from aircore coils and Mylar capacitors. Besides being a true "hi-fi" crossover, it would make an excellent choice for a super-power system. It is also possible to design and build your own crossover network from drawings and circuits published in any of the audio textbooks and cook books.

The best, most versatile and most adjustable solution would be to biamplify the Leslie. Again, it's "art", right? A Crown VFX-2 and stereo power amp would be a great setup with which to experiment.

Lastly, a crossover network consisting of a single series capacitor is a possibility (20 microfarad for 8-ohm units, and 10 microfarad for 16-ohm). It allows full-range sound to pass to the bass speaker, and high frequencies above 1 kHz to the treble speaker with a 6 dB per octave rolloff. Such a crossover network has been used successfully, and produces a very interesting and pleasing sound.

Microphone-Prepared Stock Leslie

This technique has been used very successfully in a live-music situation. A pair of small electret lavalier microphoes are permanently fastened to opposite corners of the treble horn compartment. Output from these mikes is connected to an external stereo mixer equipped with equalization - hopefully by a permanent connector fitted to the back of the Leslie cabinet - and hence to a stereo power amp and a pair of speakers located on either side of the stage. If a stereo PA rig is being used, the mikes can be fed into two channels of the front-of-house board and panned left and right. As with anything, "good taste" in EQ and general technique is required to achieve a good sound. Actually, bad taste might work well, too; try both.

Wind noise from the horn is not a problem, and minimum mechanical isolation is needed. Lack of wind noise is probably because the cabinet corners are "stagnation" or dead-air spaces. Wind noise, if present, can be reduced by using an open-cell (reticulated Scottfoam) wind screen on the mikes.

An obvious extension of this mike technique is to do the same with the lower rotor, and obtain a mixed top and bottom left and right sound. Apparently, the "top-only" technique works very well in a live situation, but might also serve the purpose for a studio Leslie.

Tandem Rotors

Slower acceleration of the lower rotor is occasionally undesirable - certainly, a matter of personal preference only. To give a more dramatic Leslie sound, the top and bottom rotors can be mechanically linked so that both will turn in sync, and the pair of horns face in the same direction. Silver Sound Systems (337 South Morris Avenue, Crum Lynn, Pennsylvania) built the little screamer with tandem rotors shown in Figure 11, which is an example of a well-prepared

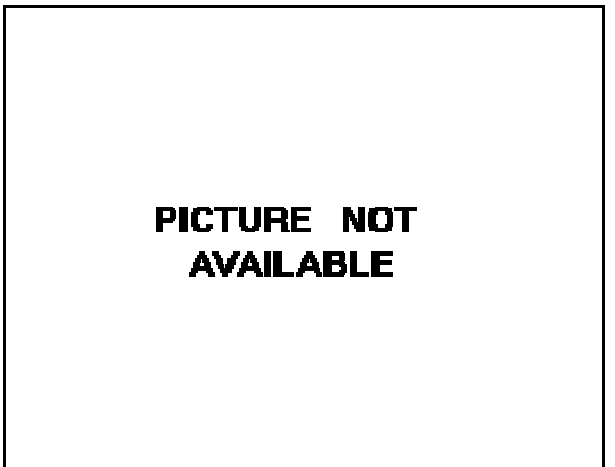

Figure 11. Customized Leslie Cabinet with tandem bass and treble rotors. the stock treble horn is driven from a tandem drive shaft coupled to the lower bass rotor. An Atlas P.A. driver is connected to the treble horn, while a JBL D120 12-inoh speaker handles the lower frequenoies.

custom Leslie unit. It enhances the Leslie action by putting full range sound into the bass unit and only high frequencies to the treble unit. This customized unit was designed for use with electric guitars.

Motor Speed Change

A really effective means of changing the rotor speed is to reach into the treble motors, and move the belt from one of the three drive pulleys to another. (Tricky, eh?) Actually, that's what they are there for; you are *supposed* to do it. My own preference is the middle pulley.

There have been a variety of speed change controls made available for Leslie motors. None have been very successful, however, since they just lower motor voltage, with the result that the motor will usually draw more current and possibly burn out. Watch out for these things. Leslie motors are A.C. induction types and, since they have no brushes, will last practically forever. However, their speed is determined by the 60 Hz frequency input, which is the same problem as varying tape-drive speed. The only solution that makes any sense is to hook-up a 115-Volt variable-speed oscillator. This can be constructed from a generator and tube amplifier that has a 115-Volt output tap. (Just like the old days, Sonny.) I am told it is really not worth the trouble though - the intermediate speed doesn't really sound very good.

STUDIO PRACTICE

As with just about anything, recording a Leslie is a matter of particular taste and purpose. You might want record the best possible recreation of a live Hammond B3/Leslie combination; you might also want to make it sound "better". You migh also want to use it as send and receive device, like an echo unit, with a high level send to the Leslie Amp, and a mono or stereo microphone receive. You could put it in a studio, in a reverb room (or in the bathroom) during the mix, or you might use it live. The possibilities are only limited by your level of creativity and/or insanity. However, the following are some standard techniques and descriptions of behavior.

Mono Recordings

I have recorded Leslies with a single microphone mounted as close as 1 foot from the treble horn, with very pleasing results. If the mike is placed even closer (within several inches) the severe amplitude-modulation effect becomes very annoying, and wind noise from the rotor at high speeds sounds like you have a helicopter in teh room. Which is a sound you might want. The same thing happens on the bass rotor, where up close there is also a lot of mechanical noise. A loose scrim will be real noisy; tighten it up. The sound from both rotors is mellower coming out of the louvres. By removing the back panels and miking the Leslie from the rear, the sound is more "direct" and defined.

Stereo And Multi-Mike Recording

Use of two mikes on the top and bottom of the cabinet is a very effective way of getting a good sound, bearing in mind the AM effects of close-miking. The *best* way I know of recording a Leslie, however, is in stereo. The left and right channels can be recorded with either a top and bottom pair of mixed mikes, or with just single mikes panned between left and right. The stereo image achieved with two pairs panned full

left and right is very exciting. Many combinations are possible though, the point being that a Leslie is capable of providng a great deal of spatial information.

I spoke with a few engineers I know about such recording techniques, and here are a few of their preferences:

Jay Mark *(Sigma sound, New York)* has been pleased with a "tight" or "direct" Leslie sound, when recording organ. His principle reason for this is because the organ is used as background and not a featured instrument; the tight sound is needed so that the organ sound is very clear and unmistakable, even when way down in a mix. Jay has used the folloing setup with good results: an RCA 77DX ribbon at back of the top rotor cabinet, about 8 inches from the treble horn, with the high-end rolled of to suit. He also uses, at the back of bottom rotor, a U87 with the lows rolled off, and mixed with the top mike to suit. He remembers experimenting with the top and bottom sound panned left and right, and not liking the effect.

Allen Sides *(Ocean Way Recording, Hollywood)* prefers a pair of tube U67s, located about 5 feet away from the Leslie, aimed midway between top and bottom rotors, and spaced 10 feet apart. The mikes are panned left and right, and recorded on two separate tracks. Allen prefers the U67's natural roll-off on the high-end for de-emphasizing the high-frequency distortion on top. He told me of recording Billy Preston, who played a Fender Rhodes electric piano with stereo vibrato, and sent each channel to two separate Leslies.

Joe McSorely *(Veritable Recording, Ardmore, Pennsylvania)* likes to use a pair of U87s mounted relatively close in top and bottom cabinets. For a "tight" organ sound, he rolls of the lows from the bottom rotor, but records the top flat. Joe echoes a repeating problem - wind noise up close - and he always uses windscreens on the mikes. He says that most organ Leslie recordings done at Veritable are on one track, but a great "fake stereo" mixdown effect can be achieved by panning the dry track to one side, and using a Harmonizer in the "doubling" mode on a second track panned full opposite. Joe describes the resultant sound as "monstrous".

Several Odd Things To Try

An interesting sound results from running a full-range 15-inch speaker with a full range signal into just the bottom rotor. It should be obvious how to do this. The slow acceleration and deceleration of this massive rotor is quite different from the top unit, as is the frequency content. Try it.

There's one other item. Iknow for a fact that certain old Leslie Cabinets have a structural resonance in the wood and probably in the louvres, but it's the real thing. The old wood is simply more resonant, and Hammond percussion notes really set it off. (It's like these guitar players running around in South Carolina pawn shops looking for the ultimate '56 Fender Strat.) I've heard Leslies on records that just have a legendary tone to them, and others that "just play regular". Go around and knock on a few new and used Leslies - especially the louvres - and see if you think I'm crazy. Anyway, the point to this was, why not try putting a FRAP pick-up on the louvres. Experiment - see if you can bring more of the sound out of the wood.

Specific Examples Of Normal Leslie Use

Normal Leslies are surgically attached to Hammond B3 or C3 organs; usually the former. There are many other brands of organs that have been played through Leslies during recording sessions, but "The Sound" which accompanies this great rock and roll Spirit of America is, pure and simple, a B3 and a Leslie. (Steinway piano, Fender Amp, Gibson, Lesl Paul, Fender Strat/Telecaster/precision Bass - all in the same breath.) The Isley Brothers used the fast Leslie all the way through their hit "Shout". Matthew Fisher combined America Soul, European Bach and B3 lower drawbars through a continuous slow chorus Leslie, and made millions listen to a "Whiter Shade of Pale" with its gorgeous organ theme. Billy Preston, Booker T. Jones and Felix Cavaliere made an art of timely speeding up and slowing down of the Leslie rotor.

These great artists (and many more) pioneered holding single notes (usually the root of the chord) and letting the Leslie provide the dramatics in rotor acceleration. Synthesizer players today *still* haven't found something as exciting. Lee Michaels had hits and toured for a long time with only his B3/Leslie and drummer Frosty. The right players could make a Leslie talk, make it scream, and make you want to dance. The list goes on forever.

...And Deviant Leslie Use (And Abuse)

Steppenwolf organist Goldie McJohn was able to coax an amazing sound from a stock Leslie. He connected the stock bass speaker directly ("full range") to the stock amp and ran the thing flat on 10 (actually it sounds like he found a way to get "11"). You can hear this very clearly on that classic track, "Born To Be Wild". The organ solo features the glorious distortion of a grossly overdriven Leslie amp, and you can hear the big bass rotor slowly speed up and slow down throughout the take. I saw Steppenwolf live at the now physically non-existent Electric Factory in Philadelphia. Goldie used the same setup on stage, only he stacked a bunch of them up right next to him, and miked one through the PA system.

Jethro Tull's *Benefit* album is considered by some to be the prototype Leslie-processed statement, and the hit "Teacher" from the LP is typical. Ian Anderson put both his flute and vocal through a Leslie, as did guitarist Martin Barre. It sounds like the Leslie was kept far away from distortion, a good example of a clean Leslie processing. I wish I know more about the particulars of this record, since it's another classic heavy.

Guitars Through Leslies

Many guitarists have used Leslies to modify the sound of their instrument. One unusual and very successful instance was Rusty Young of Poco. Rusty achieved some marvelous sounds with Poco by putting his steel guitar through a Leslie, producing a very distinctive and attractive effect. The instrumental line in Player's recent hit, "Baby Come Back", and J. Geils' soulful intro to "The Usual Place" are some more typical but outstanding examples of tasty Leslie guitar. I'm sure your lists contain a lot of others.

Personal Madness

I am arranging and putting together this article using a Norelco Dictating Machine, which has a microphone at the end of a coil cord that also acts as a loudspeaker.

You can push a button on the recorder and the sound will come out of the microphone end. By grabbing the microphone by its cord and swinging it in circles, this entire article can be played back to me with a very strange and mysterious Leslie-like effect. It's really okay. No... I'm really allright. It's just like a Leslie, you see...

Acknowledgements

Thanks to Ralph Brownlowe, Robert Rankin and Ed Sciaky (WIOQ, Philadelphia) for some priceless and valuable information used in the compilation of this article.

[This was stated by the author to be Gary Brooker, but he was not the organist for Procol Harum to play "Whiter Shade of Pale" - it was Matthew Fisher. The correction has been made here and will be forwarded to the author. -ed]